The Word Class Effect in the Picture–word Interference Paradigm

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The word class effect in the picture–word interference paradigm

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Abstract

The word class effect in the picture–word interference paradigm is a highly influential finding that has provided some of the most compelling support for word class constraints on lexical selection. However, methodological concerns called for a replication of the most convincing of those effects. Experiment 1 was a direct replication of Pechmann and Zerbst (2002; Experiment 4). Participants named pictures of objects in the context of noun and adverb distractors. Naming took place in bare noun and sentence frame contexts. A word class effect emerged in both bare noun and sentence frame naming conditions, suggesting a semantic origin of the effect. In Experiment 2, participants named objects in the context of noun and verb distractors whose word class relationship to the target and imageability were orthogonally manipulated. As before, naming took place in bare noun and sentence frame naming contexts. In both naming contexts, distractor imageability but not word class affected picture naming latencies. These findings confirm the sensitivity of the picture–word interference paradigm to distractor imageability and suggest the paradigm is not sensitive to distractor word class. The results undermine the use of the word class effect in the picture–word interference paradigm as supportive of word class constraints during lexical selection.

Keywords

Lexical access; Lexical selection; Grammatical class; Imageability; Picture–word interference

There is general consensus in the field of language production that input from the semantic system determines which lexical node will be retrieved from the mental lexicon (e.g., Caramazza, 1997; Dell, 1986; Garrett, 1980; Levelt, 1989). An unresolved issue, however, is the role that word class information plays in lexical access. Recent evidence concerning this issue comes from the observation of a word class effect in the picture–word interference (PWI) paradigm (Pechmann, Garrett, & Zerbst, 2004; Pechmann & Zerbst, 2002; Vigliocco,

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Vinson, & Siri, 2005). This evidence has been highly influential in the development of theories of lexical selection and sentence production. For instance, the word class effect in the PWI paradigm was a primary source of evidence cited in support of a recently proposed model that assumes that lexical selection is constrained by word class when producing longer grammatical strings (Dell, Oppenheim, & Kittredge, 2008). Relying on the word class effect in this way critically depends on a lexical–syntactic origin of the word class effect. Here, we challenge that interpretation. In two experiments we show that a semantic interpretation of the word class effect cannot be ruled out, and that when semantic variables are controlled, no word class effect emerges. The implication of our findings is that the word class effect in the PWI paradigm cannot be used to support a word class constrained theory of lexical selection (e.g., Dell et al., 2008).

Findings from other experimental paradigms using healthy participants, as well as research on brain-damaged patients, do, however, suggest that word class is an important organizing principle in the mental lexicon. For example, in neuropsychology, performance of aphasic patients often respects word class boundaries: Some patients are worse at producing nouns than verbs, whereas others display the reverse pattern of performance (e.g., Shapiro & Caramazza, 2003). Of central importance in this research is the question of whether word class effects arise at the lexical–syntactic or semantic level. This is not trivial because it has been demonstrated that the word class variable correlates with semantic variables such as imageability. For example, nouns tend to be more imageable than verbs (e.g., Chiarello, Shears, & Lund, 1999). Consequently, observed word class effects are potentially ambiguous between a lexical and a semantic interpretation. Despite this correlation, various studies have shown a robust word class effect when the contribution of the variable imageability is taken into account (e.g., Berndt, Haendiges, Burton, & Mitchum, 2002).

In studies of naturally occurring speech errors in the field of language production, it has long been noted that word exchanges generally respect grammatical class (e.g., Garrett, 1975; Nooteboom, 1969), and word substitutions also prefer to respect grammatical classifications (Marx, 1999; Vigliocco, Vinson, Indefrey, Levelt, & Hellwig, 2004). While the former have been ascribed to syntagmatic constraints, the latter have been argued to reflect constraints on lexical selection. A similar word class effect has been observed experimentally using the PWI paradigm. In this paradigm, participants name pictures while ignoring superimposed distractor words (for a review see Glaser & Düngelhoff, 1984; Lupker, 1979, 1982; Macleod, 1991). For example, Pechmann and Zerbst (2002) asked native German participants to name pictures of objects (e.g., “Ente”, duck) in the context of a noun (e.g., *Ballon*, balloon), or an adverb (e.g., *leider*, unfortunately) distractor word. In one naming context, the target pictures were named with a determiner+noun in a sentence context (e.g., Peter beschreibt “die Ente”, Peter describes “the duck”), while in another naming context the target pictures were named as bare nouns (e.g., “Ente”, duck). In a series of experiments, target naming latencies were found to be slower in the context of a noun than of an adverb distractor, but only when participants named the target pictures in a sentence context. In the bare noun naming condition, naming latencies were unaffected by the manipulation of distractor word class. This modulation of the word class effect by naming context was obtained in two series of experiments; one contrasted noun and closed class distractors (Experiments 1, bare noun, and 2, sentence frame; Pechmann & Zerbst, 2002), and the other contrasted nouns and adverb distractors (Experiment 4; Pechmann & Zerbst, 2002).

The pattern of findings that are reported by Pechmann and Zerbst (2002) are similar in an important respect to the pattern that is obtained when the grammatical gender of distractor words is manipulated in relation to the grammatical gender of the target pictures. La Heij, Mak, Sander, and Willeboordse (1998; see also Schiller & Caramazza, 2003; Schriefers, 1993) found that when participants named pictures of objects with a determiner+noun

response, distractor words of a different grammatical gender interfered more than distractor words of the same grammatical gender. However, when participants named the pictures with bare nouns (without a determiner) there was no effect of the grammatical gender of the distractor words. Hence, generalizing across the word class and the grammatical gender effects, it may be concluded that a "grammatical" effect of the distractor word is only obtained when participants name the target object in a syntactically constraining context.

Unfortunately, all of the noun distractor words in Pechmann and Zerbst's experiments were of a different grammatical gender from the target pictures, while the closed class and adverb distractors obviously did not have gender information. Thus, the presence of the "word class" effect only in the sentential context condition is confounded with the known effect of gender congruency in that paradigm.

Pechmann et al. (2004) attempted to address the confound of grammatical gender by replicating the word class effect in English, a language that does not mark grammatical gender. They used the same set of pictures as that in the 2002 study, as well as equivalent sets of noun and adverb distractor words. The results from their Experiments 2 and 3 (Pechmann et al., 2004) revealed that determiner+noun naming latencies were slower in the context of noun distractor words than adverb distractor words. On the basis of these results the authors concluded that naming latencies in the PWI paradigm are sensitive to distractor word class.

The putative word class effect reported by Pechmann and colleagues (2004; Pechmann & Zerbst, 2002) has been highly influential in the development and advancement of theories of lexical selection. For instance, Dell et al. (2008) have used the word class effect observed by Pechmann and colleagues to support the assumption that lexical selection is constrained by word class, when strong syntactic constraints are present. This interpretation of the word class effect in terms of lexical selection assumes that the effect arises during lexical, and not during semantic, processing. In support of this lexical explanation of the word class effect, Pechmann and Zerbst (2002) argued that the null result in the bare noun naming condition rules out a semantic source of the word class effect in the sentence naming condition: "Because we only obtained a word class effect when subjects had to engage in more syntactic processing, it is unlikely that the effect is due to semantic variables" (Pechmann & Zerbst, 2002, p. 242). In other words, a lexical interpretation of the word class effect hinges on the null result of word class in the bare noun naming conditions.

However, in addition to the confound of grammatical gender in the study of Pechmann and Zerbst (2002), there is another confound present: The distractor words from the different word classes used in the studies of Pechmann and Zerbst also differed in their imageability (see Pechmann & Zerbst, 2002, pp. 241–242)—consulting the English translations of the noun and adverb distractors from their Experiment 4 in the Medical Research Council (MRC) lexical database: average imageability for nouns, 597, and for adverbs, 280. It is well known that in the PWI paradigm, highly imageable distractor words interfere more in object naming than do abstract distractor words (Davelaar & Besner, 1988; Lupker, 1979). Thus, the fact that Pechmann and Zebrst did not observe the expected effect of distractor imageability calls into question the reliability of the null result in the bare noun naming conditions.

To summarize, Pechmann and Zerbst (2002) observed a null result in the bare noun naming contexts of their Experiments 1 and 4 despite clear differences in imageability between distractor conditions. The 2004 study, designed to rule out the potential impact of grammatical gender on the 2002 results, did not include the crucial bare noun condition. Given the important implications of the word class effect for models of lexical access (e.g.,

Dell et al., 2008), in Experiment 1 we simply sought to establish the reliability of this null result in the bare noun naming condition. We did this by attempting a direct replication of one of the findings of Pechmann and Zerbst (2002, Experiment 4). To anticipate our results, we observed (a) a difference between noun and adverb distractors in the sentence context condition (replicating Pechmann & Zerbst), as well as (b) a difference between these two distractor conditions in the bare noun naming condition (not replicating Pechmann & Zerbst). The observation of the same pattern in the sentence context and bare noun naming conditions suggests that the null result in the bare noun naming contexts reported by Pechmann and Zerbst were Type II errors. In Experiment 2 we attempted to further distinguish between a lexical and a semantic interpretation of the word class effect.

EXPERIMENT 1: SENTENCE FRAME NAMING AND BARE NOUN NAMING IN GERMAN

This is replication of Pechmann & Zerbst's (2002) Experiment 4.

Method

Participants—A total of 24 native German participants from Saarland University took part in the experiment. They were paid for their participation.

Materials and design—The same materials and design were used as those in Pechmann and Zerbst (2002, Experiment 4). A total of 30 pictures were sampled from the Snodgrass and Vanderwart (1980) database. There were four distractor conditions (identical, neutral, noun, adverb) and six stimulus onset asynchrony (SOA) conditions (−200, −100, 0, 100, 200, 300). Distractors in the identical condition were the picture names, and distractors in the neutral condition were a row of five Xs. Distractors in the noun condition were the following five nouns: Ballon (balloon), Gitarre (guitar), Vogel (bird), Zeige (goat), and Nase (nose), and distractors in the adverb condition were the following five adverbs: leider (unfortunately), stets (always), oftmal (often), immerzu (constantly), and durchaus (throughout). Noun and adverb distractor conditions were matched for length (4.5 and 6.6, respectively) and frequency (average CELEX [Baayen, Piepenbrock, & van Rijn, 1993] estimates: 18 and 51, respectively; see Pechmann & Zerbst, 2002, for further details).

The experiment consisted of two naming sessions: one in which pictures were named as a bare noun, and one in which pictures were named with a definite determiner in a sentence frame context. Each participant performed both naming sessions, and the order of the two sessions was counterbalanced across participants.

Each naming session contained six blocks. Each block contained one level of the factor SOA. The order of SOA/blocks was counterbalanced across participants. Within a particular SOA block, all 30 pictures appeared once. Of the 30 pictures, 15 appeared with an identity distractor, 5 with a noun distractor, 5 with an adverb distractor, and 5 with a neutral distractor. The assignment of a distractor to a picture was pseudorandomized for each SOA block, with the constraint that a particular picture was paired with all distractor conditions across all SOAs/blocks. The same distractor to picture assignments were used for all participants.[1]

Procedure—The procedure was similar to that used in Experiment 4 of Pechmann and Zerbst (2002). Participants were first familiarized with all the pictures in the experiment.

[1]Thus our design differed from that of Pechmann and Zerbst (2002, Experiment 4) in two ways: (a) Task order was counterbalanced; (b) SOA/block order and distractor to picture assignment were nested and not crossed.

Participants were given a booklet containing the pictures and their names. Participants were asked to provide the name of each picture and to use this name in the actual experiment. Next, they were given 12 practice trials including all four distractor conditions and all six SOA conditions. The trial structure for the sentence frame and bare noun naming conditions was as follows. In the sentence frame naming condition, participants first heard a 1,000-Hz tone of 100 ms in length. After 200 ms, one of four proper names (Anja, Thomas, Peter, Ingrid) in combination with one of four infinitive verbs—sehen (to see), betrachten (to regard), beruehren (to touch), beschreiben (to describe)—appeared on the screen for 2,000 ms. Participants were asked to produce the proper name and third person inflected verb—for example, "Peter beschreibt" (Peter describes). Next, the picture and distractor word appeared. The order and offset of picture and distractor presentation depended on the particular SOA block. Participants were asked to produce an appropriate case-marked definite determiner and a noun upon presentation of the picture. Participants in the bare noun naming condition first saw a fixation point, followed by the picture and distractor. Participants were asked to produce the name of the picture without determiner upon presentation of the picture. The trial structure for the practice trials was identical to those of the actual experiment. The experiment lasted approximately 40 minutes. Stimulus presentation was controlled by DMDX (Forster & Forster, 2003).

Analyses—The same analyses were performed as those described by Pechmann and Zerbst (2002). Erroneous responses, reaction times (RTs) shorter than 200 ms and longer 1,500 ms, and RTs that exceeded the average RT of a participant by 3 standard deviations were discarded. For the sentence frame naming condition, out of a total of 4,320 trials, 123 trials were discarded (2.8%). For the bare noun naming condition, out of a total of 4,320 trials, 143 trials were discarded (3.3%). All reported *t* tests were two-tailed.

In the analysis of variance (ANOVA) the factor SOA had 6 levels (−200, −100, 0, 100, 200, and 300), and the factor distractor type had 4 levels (noun, adverb, identity, and neutral). For both the participants (F_1) and items (F_2) analyses, these two factors were considered within-subjects factors. Analyses are presented separately for sentence frame naming and bare noun naming.

Results

An overview of RTs for each of the conditions in the sentence frame naming context and the bare noun naming context is presented in Table 1.

Sentence frame naming—In the sentence frame naming condition, the ANOVA revealed an effect of SOA, $F_1(5, 115) = 6.1$, $p < .001$; $F_2(5, 145) = 17.3$, $p < .001$, and of distractor type, $F_1(3, 69) = 33.8$, $p < .001$; $F_2(3, 87) = 43.3$, $p < .001$, and an interaction between SOA and distractor type, $F_1(15, 345) = 4.6$, $p < .001$; $F_2(15, 435) = 4.5$, $p < .001$.

A second ANOVA, which included only the two critical distractor types (nouns and adverbs), showed a main effect of SOA, $F_1(5, 115) = 11.0$, $p < .001$; $F_2(5, 145) = 20.1$, $p < .001$, a main effect of distractor type, $F_1(1, 23) = 29.6$, $p < .001$; $F_2(1, 29) = 22.8$, $p < .001$, and a trend toward an interaction between SOA and distractor type, $F_1(5, 115) = 1.8$, $p = .13$; $F_2(5, 145) = 1.8$, $p = .12$.

Planned comparisons revealed differences between nouns and adverbs at SOA −200, $t_1(23) = 3.1$, $p < .006$; $t_2(29) = 2.3$, $p < .04$, at SOA −100, $t_1(23) = 3.6$, $p < .001$; $t_2(29) = 3.1$, $p < .005$, at SOA 0, $t_1(23) = 3.2$, $p < .005$; $t_2(29) = 3.4$, $p < .003$, and at SOA 100 by subjects only, $t_1(23) = 2.5$, $p < .02$; $t_2(29) = 1.8$, $p = .09$.

Bare noun naming—In the bare noun naming condition, the ANOVA revealed an effect of SOA, $F_1(5, 115) = 4.8$, $p < .001$; $F_2(5, 145) = 16.7$, $p < .001$, distractor type, $F_1(3, 69) = 40.0$, $p < .001$; $F_2(3, 87) = 35.4$, $p < .001$, and an interaction between SOA and distractor type, $F_1(15, 345) = 5.05$, $p < .001$; $F_2(15, 435) = 4.4$, $p < .001$.

A second ANOVA, which included only the two critical distractor conditions (nouns and adverbs), showed a main effect of SOA, $F_1(5, 115) = 8.5$, $p < .001$; $F_2(5, 145) = 16.3$, $p < .001$, a main effect of distractor type, $F_1(1, 23) = 24.2$, $p < .001$; $F_2(1, 29) = 18.0$, $p < .001$, and a trend for an interaction between SOA and distractor type, $F_1(5, 115) = 2.0$, $p = .08$; $F_2(5, 145) = 1.4$, $p = .22$.

Planned comparisons revealed differences between nouns and adverbs at SOA −200, $t_1(23) = 3.3$, $p < .004$; $t_2(29) = 2.0$, $p < .06$, at SOA −100, $t_1(23) = 3.5$, $p < .002$; $t_2(29) = 3.1$, $p < .005$, at SOA 100, $t_1(23) = 3.2$, $p < .004$; $t_2(29) = 3.5$, $p < .002$, and at SOA 300, $t_1(23) = 2.8$, $p < .02$; $t_2(29) = 1.9$, $p = .07$, although only marginally in the items analyses.

Discussion

In Experiment 1 we used the same materials and procedures as those of Pechmann and Zerbst (2002, Experiment 4). Replicating Pechmann and Zerbst, we observed that target picture naming latencies were slower for noun distractors than adverb distractors in the sentence frame naming condition. However, in contrast to the null result reported by Pechmann and Zerbst for the bare noun naming condition, we observed a reliable difference between these two distractor conditions in the bare noun naming condition.[2,3] The temporal profiles (i.e., by SOA) of these two effects were comparable: In the sentence context naming condition, picture naming latencies varied as a function of distractor type at SOAs −200, −100, 0, and 100 ms, as well as in the bare noun naming condition at SOAs −200, −100, and 100 and marginally at 300 ms.

Before discussing the implication of these results, one important issue concerns the experiment-to-experiment variability that is observed using the same set of materials. In Experiment 1, a difference between noun and adverb distractors was observed at SOAs −200, −100, 0, 100, and 300 ms, while in the study of Pechmann and Zerbst (2002, Experiment 4) the same difference was obtained at SOA −100, 0, and 100 ms. A degree of variability is already present, however, in the studies reported by Pechmann and colleagues (2004; Pechmann & Zerbst, 2002). As illustrated in Table 2, the effect does not appear reliable (using the standard $p < .05$ by subjects and items, in a two-tailed t test) across the various experiments reported by Pechmann and colleagues. Our interpretation of this high degree of variability is that it is a direct result of the structure of the experimental design that has, inherently, low power. This is because, for every cell of the design (e.g., SOA −200, noun condition), there are only five observations per participant. It is thus perhaps not surprising that a high degree of variability is present given the low experimental power.

Our failure to replicate the null result in the bare noun naming condition confirms the unreliability of this effect reported by Pechmann and Zerbst (2002). Pechmann and Zerbst observed a null result in two experiments (Experiments 1 and 4). In both of those

[2]In another replication of this study ($N = 24$), we observed main effects of SOA and distractor type and an interaction between SOA and distractor type in sentence frame and bare noun naming conditions. The grammatical class effect was observed at SOAs −200, 0, and 100 ms (in both sentence frame and bare noun naming conditions, all tests two-tailed).

[3]In order to investigate whether our counterbalancing measure of the order of the sentence frame and bare noun naming conditions had an influence on the word class effect, we reanalysed the data with SOA, distractor type (nouns vs. adverbs), and task order as variables. In both the sentence frame and bare noun naming conditions, there was no main effect of task order (Fs < 1), nor an interaction between task order and distractor type (all Fs < 1). Thus, the word class effect was unaffected by the counterbalancing measure.

experiments, however, the word class distractors differed in terms of their imageability. As we argued earlier, the fact that this imageability difference did not produce the well-known imageability effect (e.g., Lupker, 1979) already undermines the reliability of the null result. In addition, the results of Experiment 1 reveal that with the same materials, reliable differences between the two word class conditions can be observed. This suggests that the null results in the two experiments reported by Pechmann and Zerbst reflect Type II errors. Such Type II errors could reasonably stem from power limitations inherent in the experimental design.

The results reported in Experiment 1 challenge an interpretation of the word class effect at the lexical level. As discussed in the introduction, this interpretation crucially depends on the absence of the word class effect in the bare noun naming condition. In our experiment, reliable differences between noun and adverb distractors in both sentence frame and bare noun contexts were found. Given that the distractors from the noun and adverb conditions also differed in terms of their imageability, the word class effect may be an imageability effect arising at the semantic level. If the word class effect observed here and by Pechmann and colleagues (2004; Pechmann & Zerbst, 2002) does not reflect a lexical effect, it would remove such evidence as support for models that assume word class constraints on lexical selection (e.g., Dell et al., 2008).

In Experiment 2, we tried to establish whether a word class effect could be obtained when the variable imageability was controlled. Given some of the methodological shortcomings and potential power limitations inherent in the design of Experiment 1, we designed a new experiment that is simplified in design and is, in many ways, more traditional and typical of the PWI paradigm. Some of the key changes to the method are as follows. Instead of using noun and adverb distractors for which it is difficult to collect imageability ratings, noun and verb distractors were selected for which imageability ratings were available (Chiarello et al., 1999). The availability of these ratings allowed for an orthogonal manipulation of the variables word class and imageability. In addition, the power of the experimental design was increased by using only a single SOA (i.e., SOA = 0). This particular SOA was selected as it is the most widely used SOA in the PWI literature, especially for visually presented distractor words (cf. Damian & Martin, 1999), and studies focused on effects that putatively occur at the lexical level. Finally, in the sentence frame naming condition, participants named the set of experimental items in the singular, but they also named a set of filler items in the plural. This manipulation of number was included to further enforce morphosyntactic processing of the target.

Many aspects of the original design were maintained: Participants named pictures of objects in a sentential and a bare noun naming context. The preambles used in the sentence context condition were comparable. If a word class effect is obtained when imageability is controlled, this would suggest a lexical–syntactic origin of the word class effect. If, however, no word class effect is obtained when imageability is controlled, this would be consistent with a semantic origin of the word class effect. Finally, based on previous research, independent effects of imageability (e.g., Lupker, 1979) were expected.

EXPERIMENT 2: IMAGEABILITY AND WORD CLASS IN BARE NOUN AND SENTENCE FRAME NAMING CONDITIONS

Method

Participants—A total of 48 native English speakers, students at Harvard University, took part in the experiment. Half of the participants took part in the bare noun naming and half in

the sentence frame naming condition. All participants were paid or received course credit for their participation.

Materials and design—A total of 32 pictures with high name agreement (>90%) were chosen from the Snodgrass and Vanderwart (1980) picture database (see Appendix). Each picture was paired with four different sets of words. The four sets were: (a) high-imageable nouns; (b) low-imageable nouns; (c) high-imageable verbs; and (d) low-imageable verbs. Targets and distractor words had neither semantic nor phonological relationships. All words were selected from the Chiarello et al. (1999) database. This database contains imageability ratings and other lexical statistics for over 1,100 nouns and verbs. All selected nouns were pure nouns, meaning that there was no other part of speech besides the noun reading listed in Francis and Kučera (1982). The same was true for all selected verbs.

The set of nouns and verbs were matched on their imageability ratings, lexical frequency, word length, and number of syllables (all *t*s < 1). Between the high- and low-imageable words, imageability ratings differed, $t(62) = 12$, $p < .01$, but their lexical frequency, $t(62) = 1.5$, $p = .14$, word length ($t < 1$), and number of syllables, $t(62) = 1.6$, $p = .1$, did not. For an overview of average lexical properties of the experimental items see Table 3.

The preambles for the sentence frame naming condition were constructed by choosing one of four proper names (i.e., John, Peter, Mary, Emma), one of four transitive verbs in their infinitive form (i.e., seeing, observing, watching, describing), and a determiner specified for number (i.e., the, some). The experimental items always followed the preambles containing the determiner “the”, while a set of 64 filler items followed the preambles containing the determiner “some”. These filler items were constructed by pairing the set of 32 experimental pictures with a new set of 32 nouns and 32 verbs selected from the same source as above. Thus, in total there were 192 items in the sentence frame naming condition and 128 items in the bare noun naming condition. Finally, 16 practice items were constructed by pairing 8 pictures that were not in the experimental set with 8 pure nouns and 8 pure verbs selected from the same source as above.

Procedure—Participants were seated in front of a PC with a 17″ CRT monitor with an attached microphone. Experimental software and voice key measurement was provided by DMDX (Forster & Forster, 2003).

There were three parts in the experiment. In the first part participants were familiarized with the 40 pictures in the experiment. On each trial a participant saw a picture on the screen for 2,000 ms and named the picture. Participants were corrected by the experimenter if an incorrect name was produced. After 1,500 ms the next trial started. The second and third parts were identical in trial structure, but in the second part participants practised the experimental task, while the third part was the experiment proper. Participants in the bare noun naming condition were told they would see a picture on the screen that they would have to name as fast and accurately as possible. Participants in the sentence frame naming condition were told that they would first see a combination of a proper name, an infinitive verb, and a determiner (i.e., John-seeing-the),[4] which would be followed by the presentation of a picture. They were told to produce a correct verb phrase upon seeing the preamble (e.g., “John sees the”) before the presentation of the picture and to produce the picture name (e.g., “car”) as fast and accurately as possible upon its presentation. They were also told that sometimes the preamble would contain the determiner “some” (e.g., John-seeing-some), in which case they should name the presented picture in the plural (e.g., “cars”).

[4]The determiner was included in the preamble to avoid potential strategic behaviour and its negative effect on voice key measurements that could arise when every utterance starts with the same word (“the”).

In the bare noun naming condition, a fixation point appeared on each trial (700 ms), followed by a blank screen (200 ms), followed by the target picture (1,500 ms), and finally followed by a blank screen (1,500 ms). In the sentence frame naming condition, a fixation point appeared on each trial (700 ms), followed by a blank screen (200 ms), followed by the preamble in which the proper name, infinitive verb, and determiner were separated by hyphens and were presented in the middle of the screen (2,000 ms), followed by a blank screen (400 ms), and finally followed by the target picture (1,500 ms) and a blank screen (1,500 ms). The bare noun naming condition lasted about 20 minutes and the sentence frame naming condition about 30 minutes.

Analyses—All trials on which participants produced incorrect responses, hesitated, or produced no response were discarded from further analysis. In addition, all trials on which the reaction times were less than 300 ms or exceeded the participant's average overall RT plus 2.5 times the participant's overall standard deviation were also excluded from further analysis. From a total of 3,072 observations, 47 trials were discarded (1.5%) in the bare noun naming condition, and 104 trials were discarded (3.4%) in the sentence frame naming condition.

We performed a repeated measures ANOVA with two crossed factors: grammatical class (noun vs. verb) and imageability (high vs. low). These factors were considered as within-subjects factors for the participant (F_1), and item (F_2) analyses. Separate analyses were carried out for the bare noun and sentence frame naming conditions.

Results

Sentence frame naming condition—For an overview of RTs for each of the conditions in the sentence frame and bare noun conditions, see Table 4. The RT analysis revealed a main effect of imageability, $F_1(1, 23) = 14.07$, $p < .001$; $F_2(1, 31) = 6.52$, $p < .02$, no main effect of grammatical class, and no interaction between imageability and grammatical class, all Fs < 1. The error analysis did not reveal any significant effects, all Fs < 1.

Bare noun naming condition—The RT analyses revealed a main effect of imageability, $F_1(1, 23) = 20.2$, $p < .001$; $F_2(1, 31) = 13.8$, $p < .001$, no main effect of grammatical class, and no interaction between imageability and grammatical class, all Fs < 1. The error analysis revealed no significant effects, all Fs < 1.

Discussion

In both the bare noun and sentence frame naming conditions, an effect of distractor imageability was found. By contrast, using the same set of materials, in both naming conditions, no effect of distractor word class was found. These results suggest that the word class effect cannot be separated from the imageability effect.

An alternative interpretation of these results could ascribe the lack of the word class effect to the ineffectiveness of the sentence context condition. There are two reasons why this is unlikely. First, participants produced nouns in both singular and plural. Such a morphosyntactic operation should enhance the syntactic processing of the target. In addition, RT measurement took place from noun onset, thereby avoiding potential strategic issues from repeating the same determiner on every trial.

GENERAL DISCUSSION

The two experiments presented here investigated the word class effect in the picture–word interference paradigm. Experiment 1, a replication of Pechmann and Zerbst (2002,

Experiment 4), revealed a word class effect in the sentence frame condition (replicating Pechmann & Zerbst) and in the bare noun naming condition (contra Pechmann & Zerbst), suggesting that the word class effect could potentially reflect an imageability effect. Experiment 2 revealed that the word class effect could not be separated from the imageability effect: Naming latencies were sensitive to distractor imageability (see Lupker, 1979), but were not sensitive to distractor word class when imageability was controlled.

These results conflict with the results of Pechmann and colleagues (2004; Pechmann & Zerbst, 2002). In contrast to their findings, we observed a word class effect in the bare noun naming condition of Experiment 1. Given that the noun and adverb distractors in this experiment were not matched for imageability, a semantic explanation for the putative word class effect in the PWI paradigm can no longer be ruled out. In addition, in Experiment 2, we show that when distractor imageability is controlled, no word class effect emerges. The important implication of this is that the word class effect observed by Pechmann and colleagues cannot be cited in support of models that assume that lexical selection is constrained by word class (e.g., Dell et al., 2008).

While our focus has been on the study conducted by Pechmann and Zerbst, they are not the only ones to have observed a word class effect using the PWI paradigm. Vigliocco et al. (2005) used the picture–word interference paradigm with verb targets. Native Italian participants named pictures of actions in the context of distractor words that were either from the same word class (i.e., verbs in the infinitive form) or from a different word class (i.e., nouns with accompanying determiner). Orthogonally crossed with the noun–verb manipulation in the distractor words was a manipulation of whether the distractors were semantically related or unrelated to the target actions. Finally, the target action pictures were named either in the infinitive form or in the third person inflected form. It was found that the manipulation of semantic relatedness affected target naming latencies for both noun and verb distractors and for naming the target actions in both the infinitival and inflected form. In contrast, verb distractors interfered more than noun distractors (collapsing across the manipulation of semantic relatedness) only when participants produced the target verbs in the inflected form.

The observation of a word class effect in the inflected verb condition of Vilgiocco et al. (2005) seems to contrast with the absence of the word class effect in Experiment 2 reported here. However, there are some aspects of the experimental design employed by Vigliocco et al. that limit a clear interpretation of their word class effect. First, the word class effect reported by Vigliocco et al. is assumed to reflect a contrast between the noun and verb distractor conditions. However, also included in the noun distractor condition was a determiner, in order to disambiguate alternative readings of the noun. Given that it has recently been shown that determiner distractors exert their influence on picture naming latencies in the PWI paradigm (Alario, Ayora, Costa, & Melinger, 2008), it is no longer obvious that the presence of the determiner can simply be ignored and that the word class effect only reflects a contrast between the noun and verb distractor conditions. In addition, a recent study by Iwasaki, Vinson, Vigliocco, Watanabe, and Arciuli (2008) failed to obtain the word class effect in Japanese, even though their experimental design paralleled that of Vigliocco et al. Iwasaki et al. interpreted the discrepancy between their results and those of Vigliocco et al. in terms of cross-linguistic differences. However, in light of the within-language nonreplication reported herein, their results cast further doubt on the robustness of the word class effect in the PWI paradigm.

Mahon and colleagues (Mahon, Costa, Peterson, Vargas, & Caramazza, 2007, Experiment 3) also investigated the impact of distractor word class on picture naming within a larger study on semantic category effects in the PWI paradigm. In their experiment participants named

pictures of objects in the context of noun and verb distractors that were matched for imageability. The results revealed that naming latencies were sensitive to the word class of the distractor word. However, they also showed that the word class effect was mainly carried by the highly imageable words (see their Figure 1). On the basis of those results, the authors argued that their result can be accounted for in terms of response relevance and not in terms of word class.

To conclude, the results reported here confirm the sensitivity of the picture–word interference paradigm to effects of distractor imageability (e.g., Davelaar & Besner, 1988; Lupker, 1979), but not to distractor word class. These results undermine the use of the word class effect in the PWI paradigm in support of a word class constrained theory of lexical selection (e.g., Dell et al., 2008). This conclusion does not imply that such a theory of lexical selection is wrong, or that empirical support for such a theory cannot be found with other tasks or measures (cf. Melinger & Koenig, 2007, for evidence from word class priming; Marx, 1999; Vigliocco et al., 2004, for evidence from speech errors). The implication is rather that, at present, one can no longer use the word class effect in the PWI paradigm in its support.

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Table 1

Average naming latencies and error percentages for the bare noun and sentence frame naming conditions in Experiment 1

	Stimulus onset asynchrony						
Distractor	**−200**	**−100**	**0**	**100**	**200**	**300**	**M**
Sentence frame condition							
Noun	670 (2.5)	677 (8.3)	656 (4.2)	623 (2.5)	584 (5.0)	592 (5.0)	634
Adverb	627 (4.2)	637 (4.2)	608 (3.3)	589 (3.3)	582 (0.8)	579 (4.2)	604
Neutral	606 (5.0)	602 (0.8)	584 (4.2)	579 (1.7)	574 (5.8)	583 (2.5)	588
Identity	556 (0.8)	556 (1.9)	559 (2.2)	558 (1.7)	558 (2.2)	579 (2.8)	561
M	615	618	602	587	575	583	
Bare noun condition							
Noun	703 (3.3)	690 (3.3)	652 (4.2)	675 (5.0)	601 (6.7)	623 (2.5)	657
Adverb	663 (3.3)	642 (3.3)	637 (5.0)	613 (3.3)	598 (4.2)	590 (6.7)	624
Neutral	629 (3.3)	616 (3.3)	612 (3.3)	594 (6.7)	590 (2.5)	608 (3.3)	608
Identity	593 (2.2)	569 (3.1)	582 (1.9)	584 (3.1)	590 (2.5)	604 (2.5)	587
M	647	629	621	616	595	606	

Note: Negative values of stimulus onset asynchrony (SOA, in ms) mean that word onset preceded picture onset, while zero and positive values indicate that the distractor word coincided with or followed picture onset. Error percentages in parentheses.

Table 2

Overview of the grammatical class effect as a function of SOA in the different experiments reported by Pechmann and colleagues

	SOA					
Experiment	**−200**	**−100**	**0**	**100**	**200**	**300**
2002; Exp. 2		**†	**†	**		
2002; Exp. 3		*	**	**		
2002; Exp. 4		**	**	**		
2002; Exp. 5[a]			**	*	**	
2004; Exp. 1	**	**	*	*†		
2004; Exp. 2		*	*†			
2004; Exp. 3	*	*†	**†			

Note: SOA = stimulus onset asynchrony (in s). 2002 and 2004 refer to Pechmann and Zerbst (2002) and Pechmann, Garrett, and Zerbst (2004), respectively. Studies in the 2002 paper and in Experiment 1 of the 2004 paper were with German participants, and in Experiments 2 and 3 in the 2004 paper were with English participants.

[a]With auditory distractors.

*$p < .05$ for subjects only.

**$p < .05$ for subjects and items.

†one tailed *t* tests.

Table 3

Overview of the average lexical properties of low- and high-imageable noun and verb distractors in Experiment 2

	Noun distractors		Verb distractors	
	Low imageable	**High imageable**	**Low imageable**	**High imageable**
Imageability	2.8	5.3	2.9	5.3
Frequency	3.8	3.6	3.8	3.6
Word length	5.1	5.3	5.3	5.4
Syllables	1.7	1.6	1.8	1.6

Note: Imageability estimates from Chiarello et al. (1999); frequency estimates from Hyperspace Analog to Language (HAL) (Burgess & Livesay, 1998) as reported in Chiarello et al. (1999).

Table 4

Average naming latencies for the bare noun and sentence frame naming conditions in Experiment 2

	Bare noun			Sentence frame		
	Low ima	**High ima**	**Diff**	**Low ima**	**High ima**	**Diff**
Nouns	665 (1.1)	679 (2.3)	14	694 (3.4)	709 (3.1)	15
Verbs	661 (1.0)	680 (1.5)	19	696 (3.0)	706 (3.5)	10
Difference	4	−1		−5	3	

Note: Naming latencies in ms. Error percentages in parentheses. Ima = imageability. Diff = difference.

APPENDIX

Pictures and word distractors used in Experiment 2

Picture	Noun low ima	Noun high ima	Verb low ima	Verb high ima
CAT	zeal	barley	impale	holler
BOTTLE	wit	cavern	deny	inject
LADDER	virtue	chore	omit	plead
APPLE	unit	tube	ignore	bleed
ARROW	vigor	estate	rouse	relax
CHAIR	trivia	grove	refine	fetch
GUITAR	prose	diary	adapt	vanish
SPOON	topic	comedy	apply	borrow
PENCIL	tact	coward	elude	kidnap
CARROT	realm	joy	hire	beg
PIPE	thrift	famine	amass	squirm
KEY	source	nature	manage	teach
HELMET	quota	prayer	err	pierce
TRUCK	sentry	gloom	plod	cater
BOOT	fever	morale	carve	devise
TABLE	policy	keg	assume	sew
CAMERA	ordeal	ridge	defer	grieve
BED	status	gadget	intend	topple
GLOVE	fate	warden	oppose	scorch
HOUSE	intent	soul	notify	adopt
LAMP	satire	tremor	acquit	peddle
WINDOW	extent	creek	convey	drown
PIANO	mercy	nozzle	enact	exhale
DOG	era	width	impose	harass
FLOWER	hub	quart	devote	throb
BICYCLE	folly	plaza	delve	erase
BOOK	pang	talent	avert	wander
FLAG	basis	youth	imply	bury
GHOST	clause	valve	compel	starve
HORSE	merger	slogan	exert	devour
FROG	deceit	pantry	revert	sizzle
STAR	habit	poet	retain	flee

Note: Ima = imageability.